

Biopower

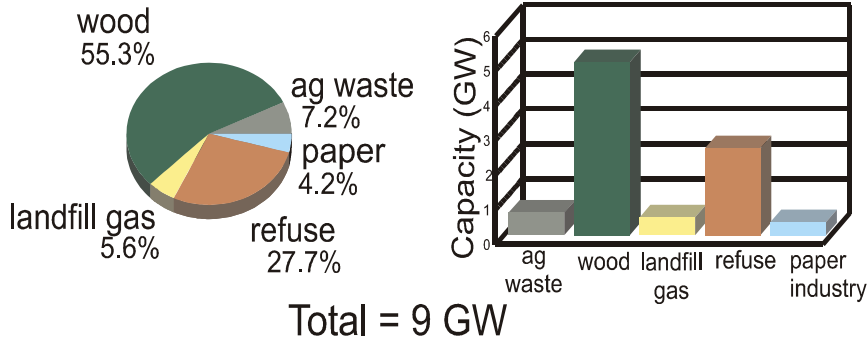
Kevin Craig

National Renewable Energy Laboratory

Biopower

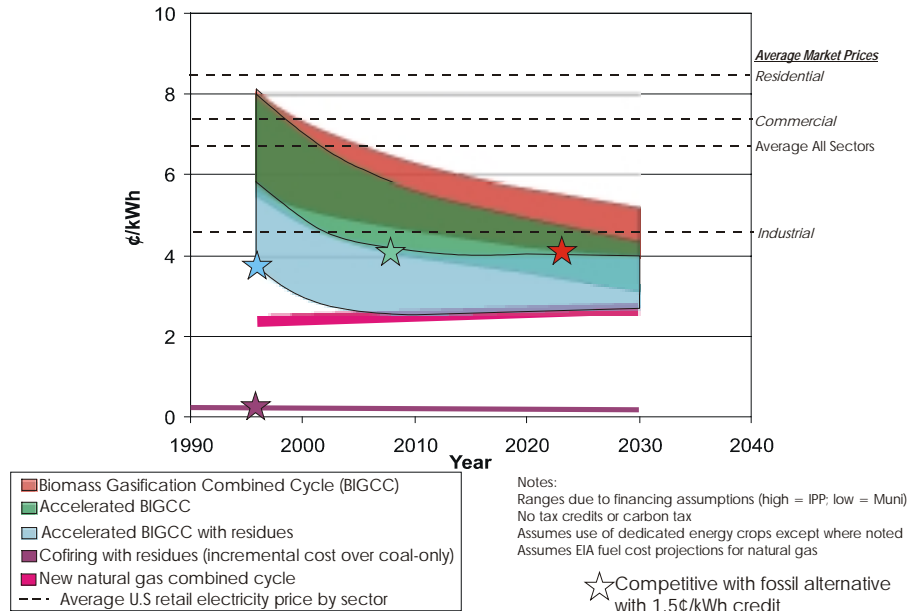
Grid Connected Electricity from Renewables

sources: UDI, Edison Electric Institute, EIA



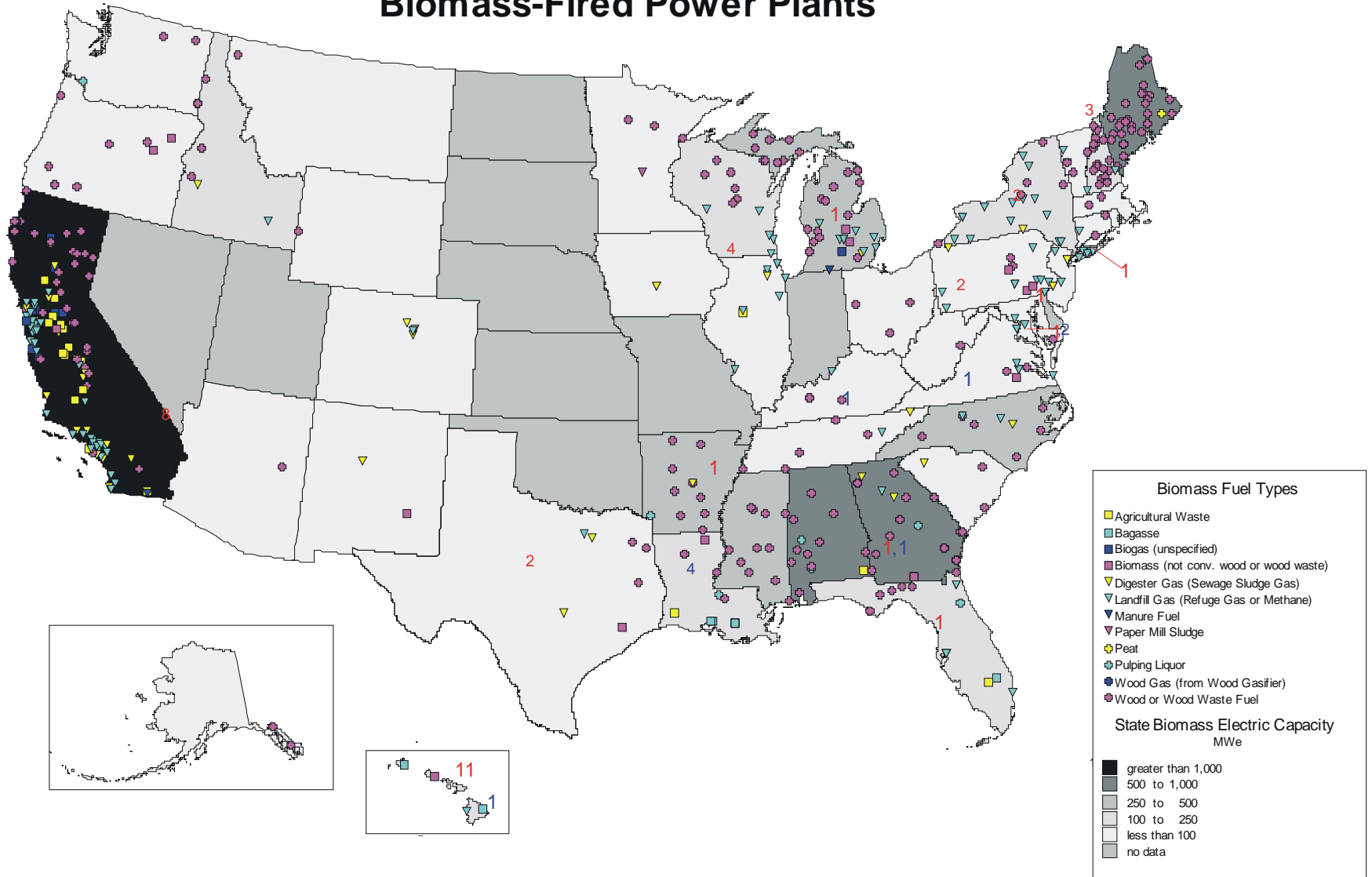
note: amount reported for paper industry represents only the total capacity dedicated to producing electricity for the grid

Projected Cost of Electricity from Biomass

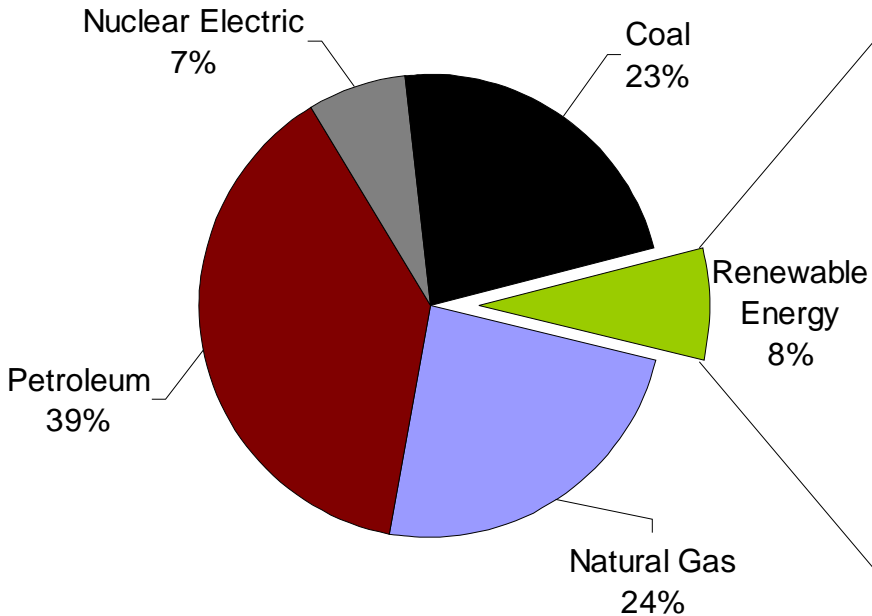


- Substantial existing industry (1% of U.S. generating capacity)
- Entirely residue based (agricultural, forest products, etc.)
- Future fuel will be blend of residues and energy crops
- Using biomass for power generation reduces emissions of sulfur oxides (SOx), nitrogen oxides (NOx), and carbon dioxide (CO2)

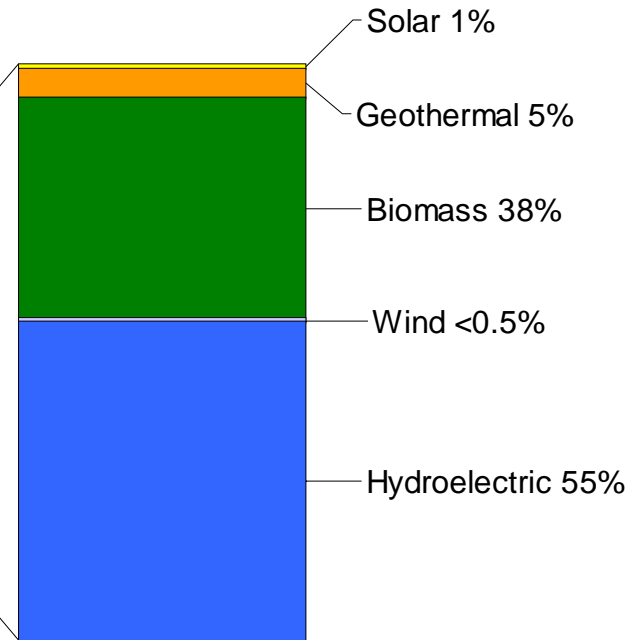
Biomass-Fired Power Plants



All Energy Sources (94.2 Quadrillion Btu)



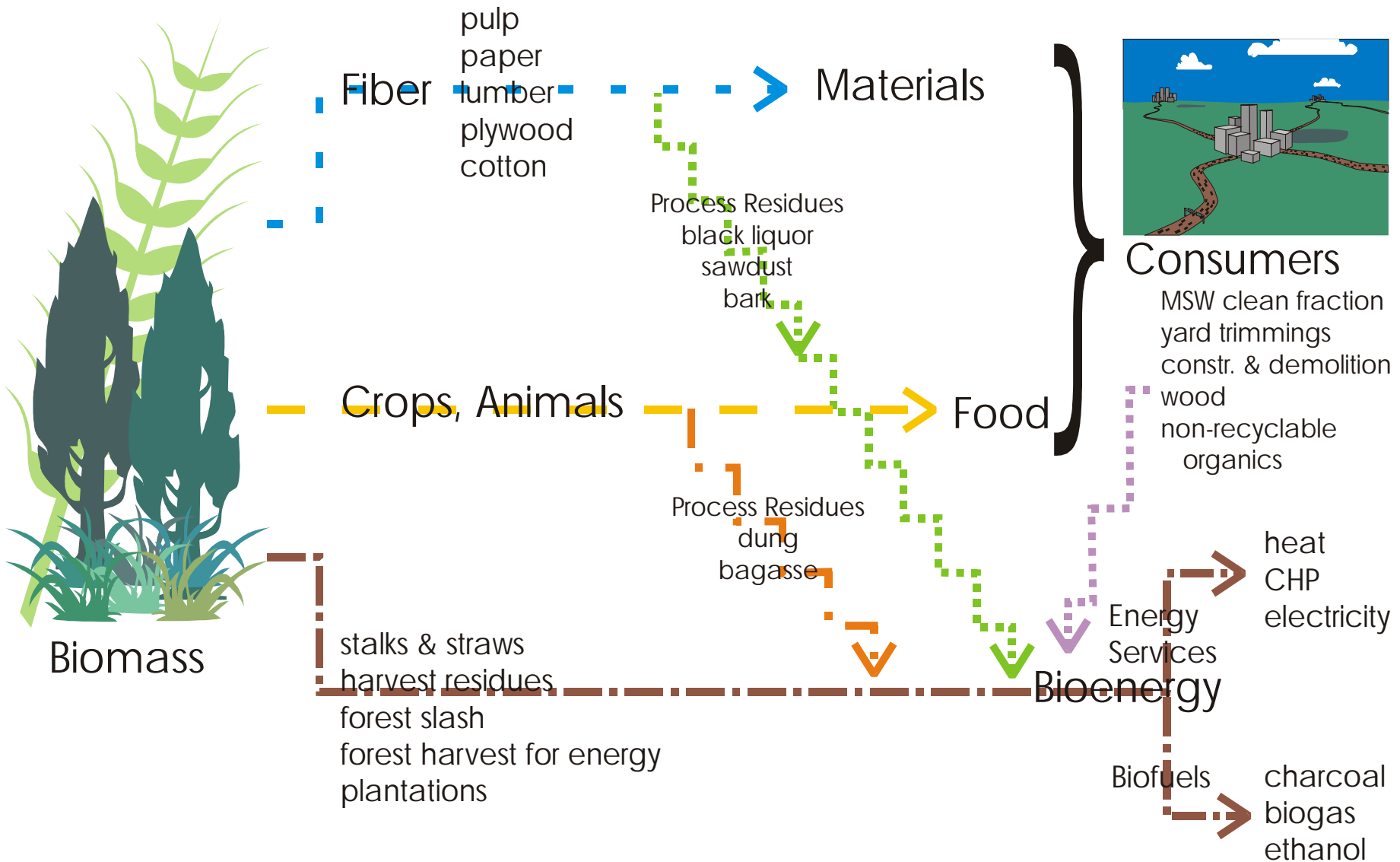
Renewable Energy Sources (7.1 Quadrillion Btu)



Totals may not equal sum of components due to independent rounding.

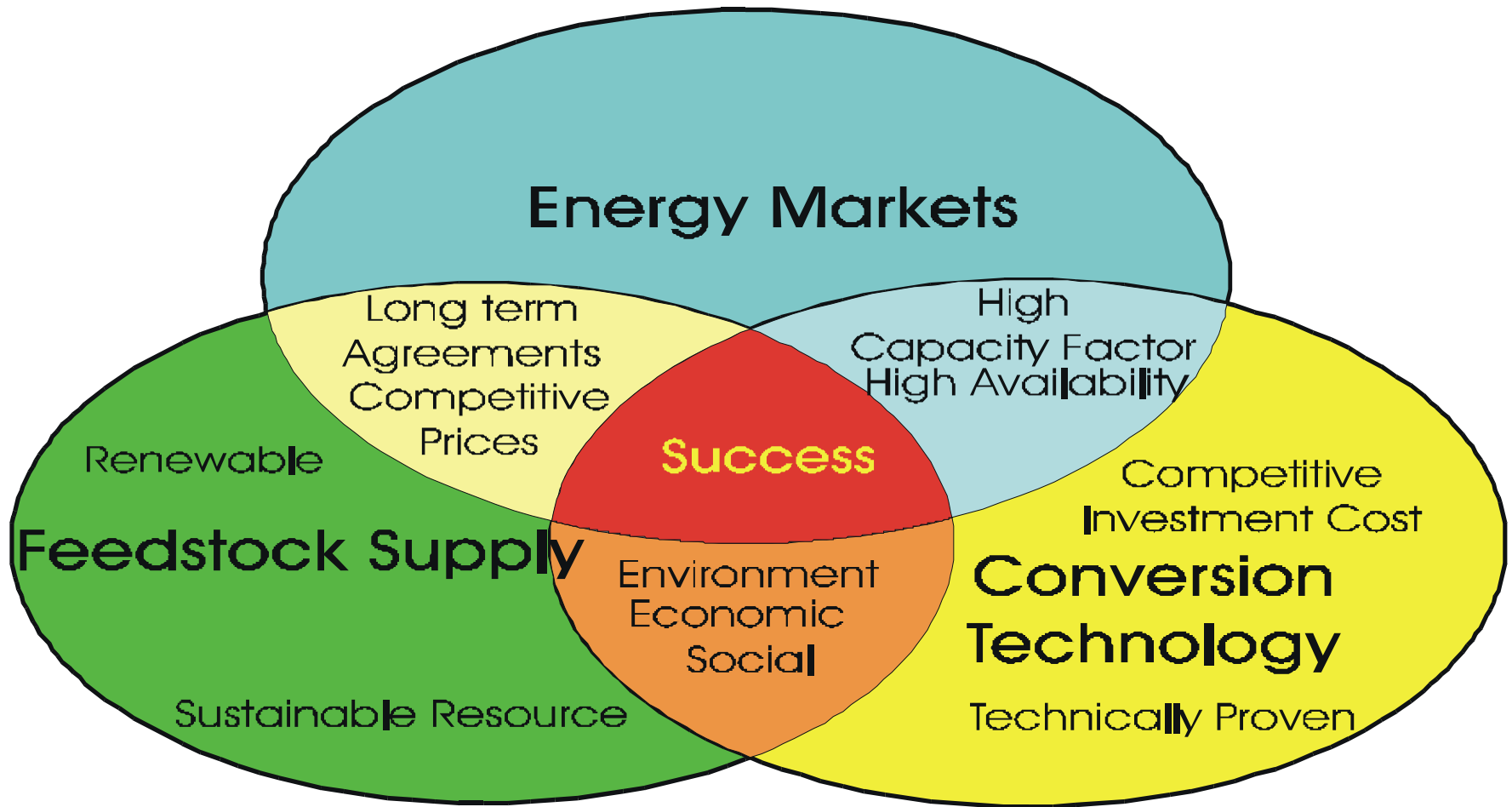
Source: EIA's Renewable Energy Annual 1998

Biomass & Bioenergy Flows

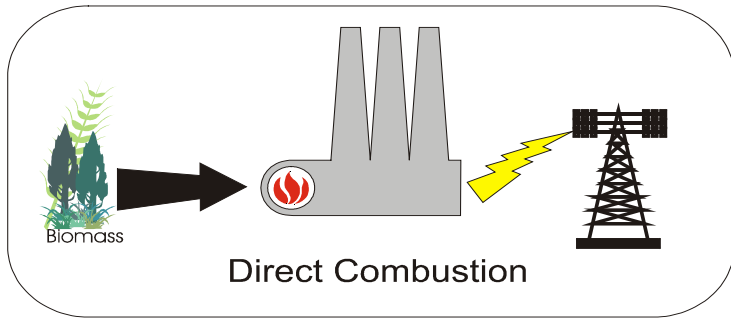


Biomass and Bioenergy

Criteria for Success



Paths to Biopower



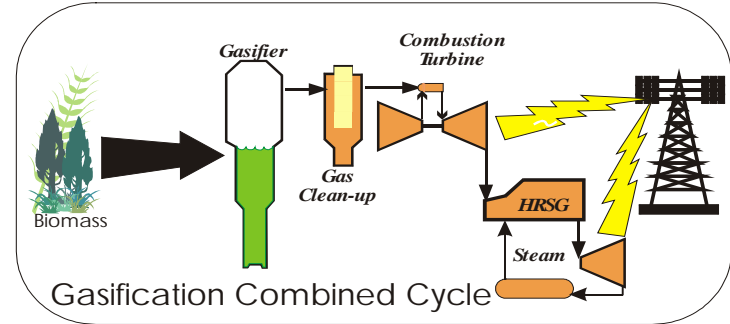
Direct Combustion

Existing Industry

7,000 MW

Average 20% Efficiency

100% Residue Based



Gasification Combined Cycle

High Efficiency Options

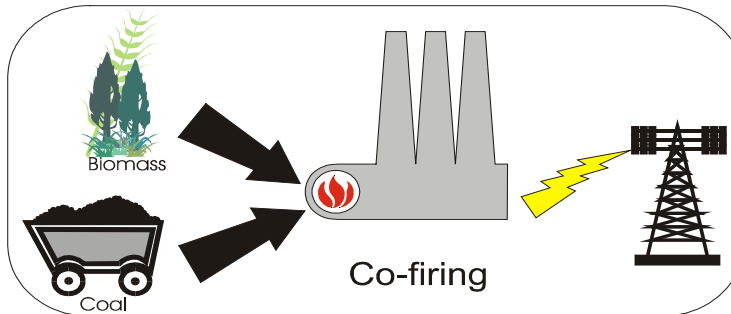
Gas Turbines, Fuel Cells

40+% Efficiency

Significant Interest by Cogenerators

e.g. Pulp & Paper industry

Small Demo's in Europe & U.S.



Co-firing

Offsetting Emissions of Existing Fossil Generation - A Low Cost Option

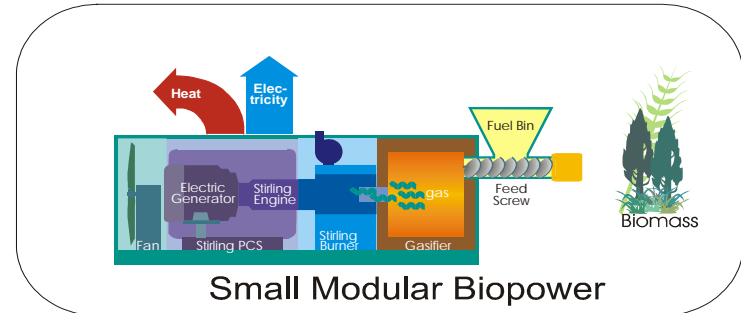
Several successful Demo's

35% Efficiency

SOx and Some NOx Reduction

Market Encourages Energy Crops

Results in No Capacity Addition



Small Modular Biopower

Distributed Generation/Village Power

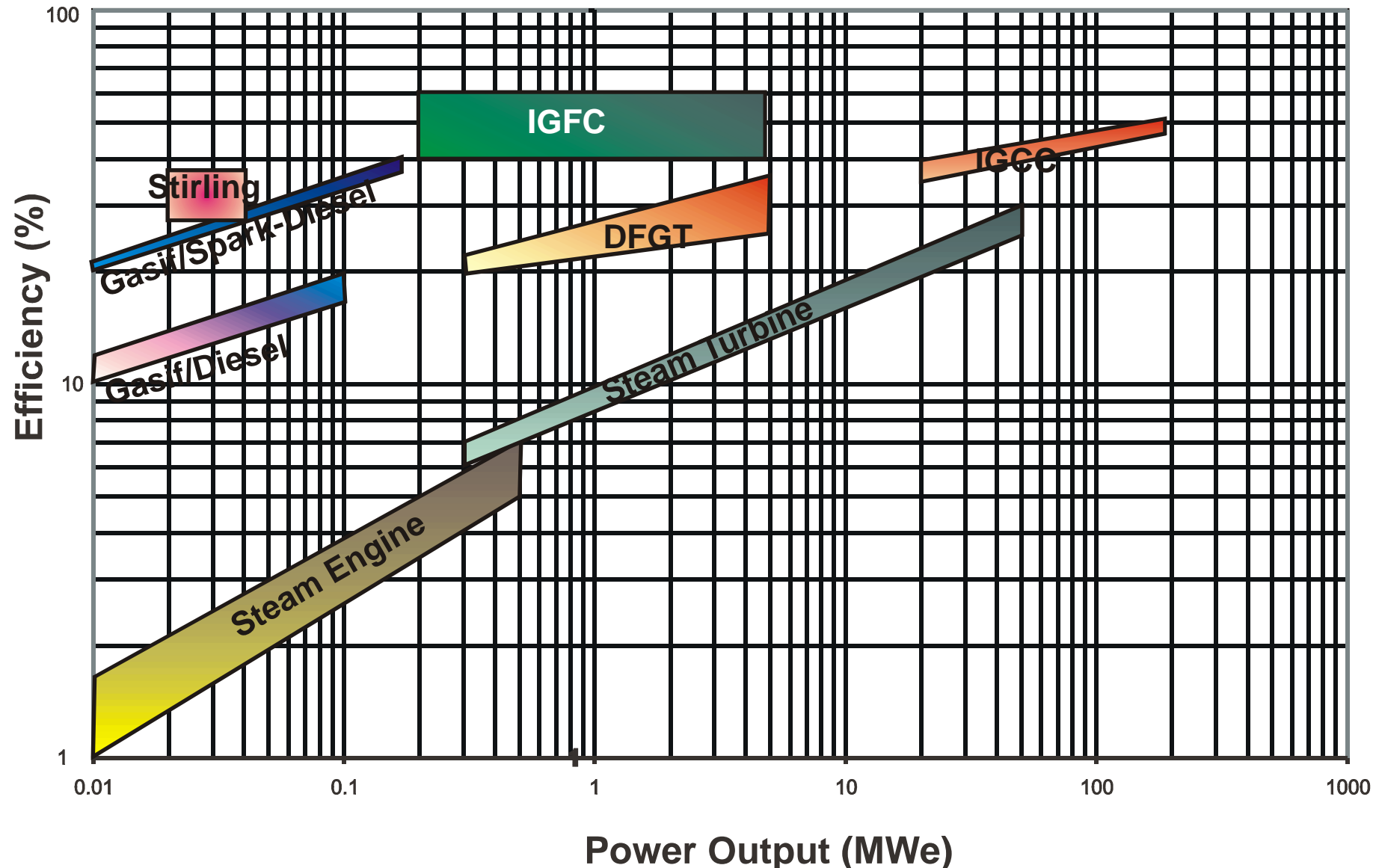
Micro-Turbines, Fuel Cells, Stirling Engines

Fuel Flexible; Efficient

Simple to Operate

Minimal Environmental Impacts

Relationship of Various BioPower Technologies



Development and Commercialization Projects

Biomass Power for Rural Development

Integrated demonstration projects

- Salix Consortium
Hybrid willows for cofiring in NY
- Chariton Valley
Switchgrass for cofiring in SE Iowa
- Energy Performance Systems (EPS)
Novel tree harvesting for Whole Tree Burner(TM) in Minnesota

Battelle Indirect Gasifier Demonstration Project

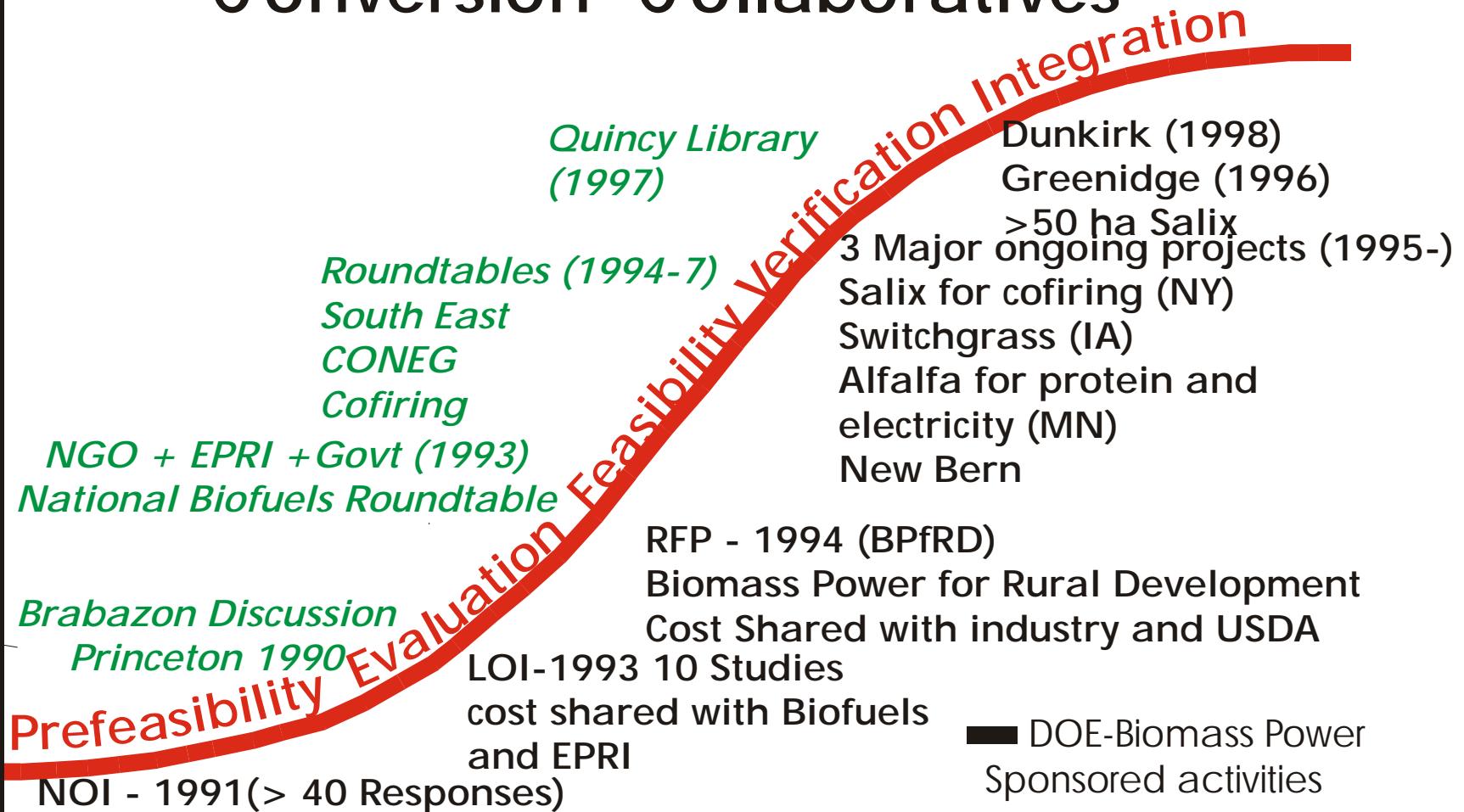
- Biomass fuel gas cofired in existing 50 MW wood-fired boiler in Burlington, VT
- Tightly coupled to Pulp and Paper Industries of the Future Program

Small Modular Biopower Systems

- Target: Distributed generation and village power systems
- Size: 5kW - 5 MW
- Goals: Clean, efficient, fuel-flexible, economically competitive
- Status: 10 feasibility studies completed; prototype testing in CY2000

Integrated Feedstock Production and Conversion Collaboratives

Cumulative Level of Effort



Research

Development

Commercial

Stage of Development

Biomass Power for Rural Development New York Willow Project (Salix Consortium)

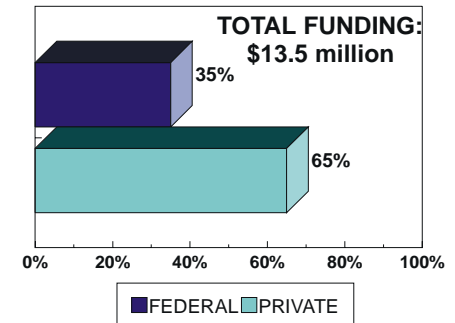
► **Location:** central & western New York

► **DOE Partners:**

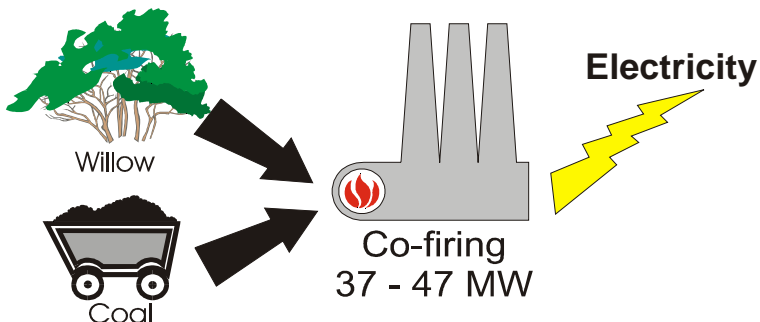
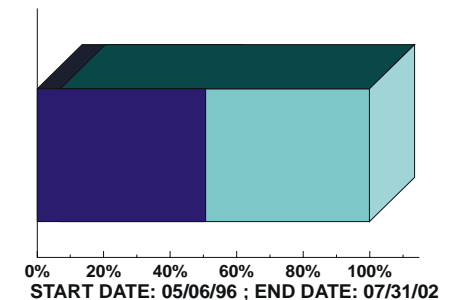
- Niagara Mohawk Power Corp.
- South Central NY Res. Cons. & Dev. Agency
- 26 local farmers & NY grape growers
- New York State Gas & Elec.
- NY Gas
- General Public Utilities
- Burlington Electric Department
- SUNY--Cornell--Univ. of Toronto
- NYSERDA
- Gas Research Institute
- EPRI
- Case Corp.
- John Deere Corp.
- USDA



PROJECT COST-SHARING



PROJECT DURATION
% DURATION COMPLETED



Recent Accomplishments:

- 140 acres of willows planted
- System retrofit and test burn at NYSEG's Greenidge Station
- Design and fuel supply plan completed for NIMO Dunkirk Station
- Modified willow planter tested

Biomass Power for Rural Development

Chariton Valley Co-firing Project

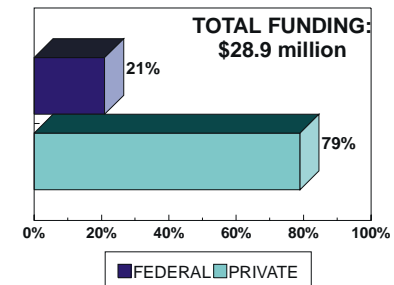
► Location: South-central Iowa

► DOE Partners:

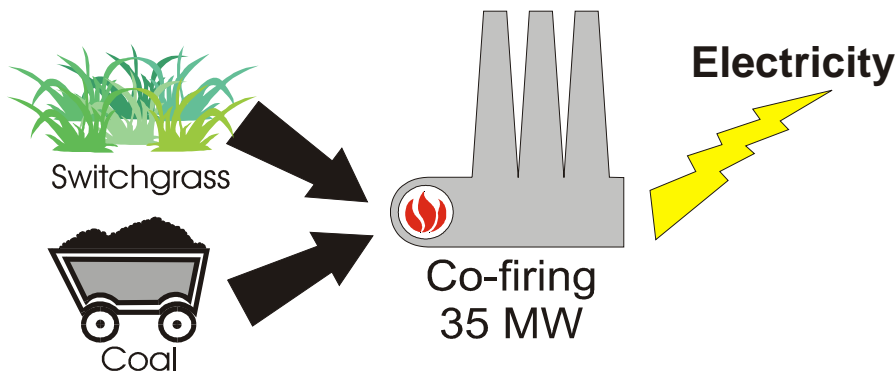
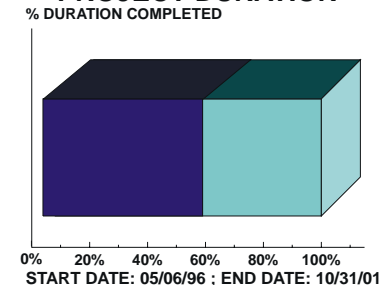
- Chariton Valley RC&D
- IES Utilities (Ottumwa Station)
- Local Farmers & Landowners
- Iowa Farm Bureau Federation
- Iowa State University
- R.W. Beck (Engineering Firm)
- Iowa Dept. of Natural Resources
- Iowa Division of Soil Conservation
- Energy Research Corp.
- ABB/CES (Asea Brown Boveri/Combustion Engineering Systems)
- Soil and Water Conservation Districts



PROJECT COST-SHARING



PROJECT DURATION



Recent Accomplishments:

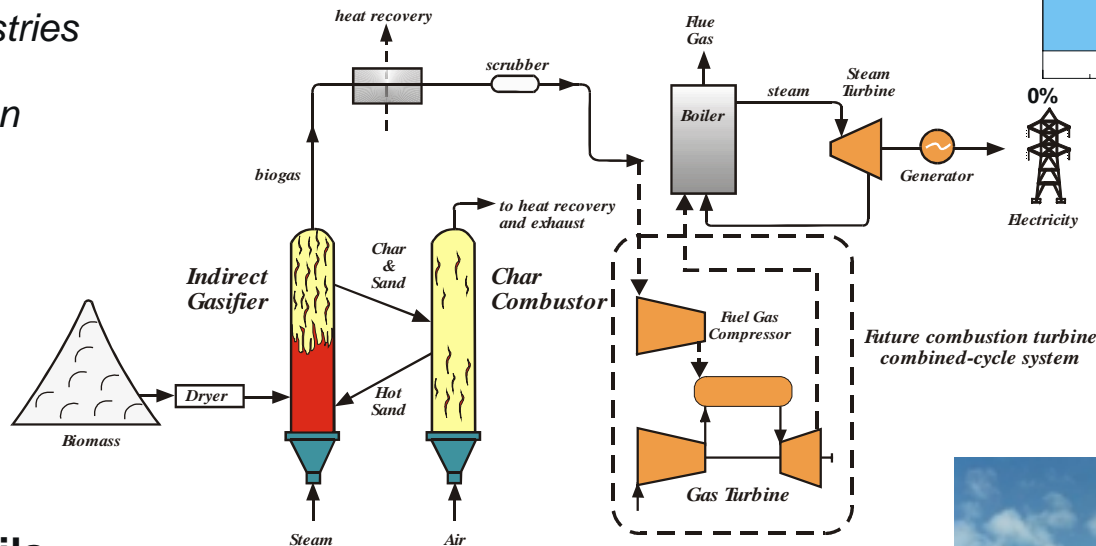
- Growers cooperative established
- 4,000 CRP acres committed to project
- Design of plant modifications for test-burn in progress

Vermont IGCC Scale-up Project

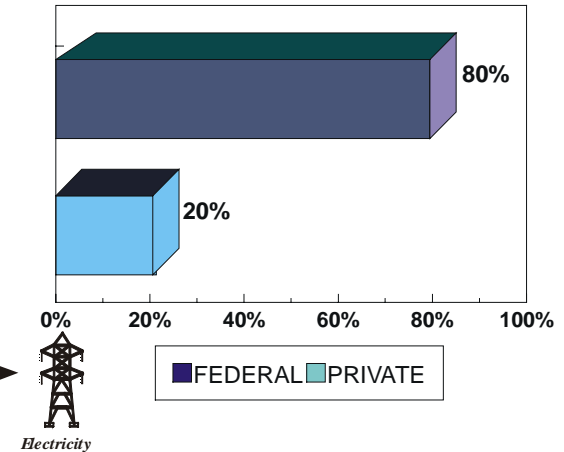
► **Location:** Burlington, Vermont

► **DOE Partners:**

- *FERCO*
- *Burlington Electric Dept.*
- *Battelle Memorial Institute*
- *McNeil Power Station*
- *Zurn Industries*
- *IEA Zurn*
- *OEC/Enron*
- *Bechtel*
- *NREL*



PROJECT COST-SHARING



► **Project Details:**

- **Project Size/Capacity:**
15 MW
- **Technology:**
Indirect Gasification
- **Feedstock:**
Willow (200 ton/day)



DOE Biomass/Coal Cofiring Activities

Locations:

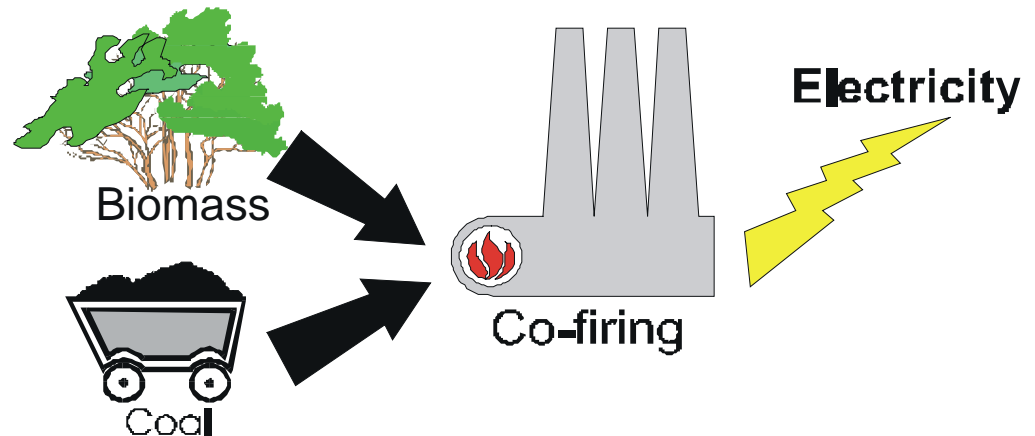
- New York
- Pennsylvania
- Indiana
- Alabama
- Vermont

DOE Partners:

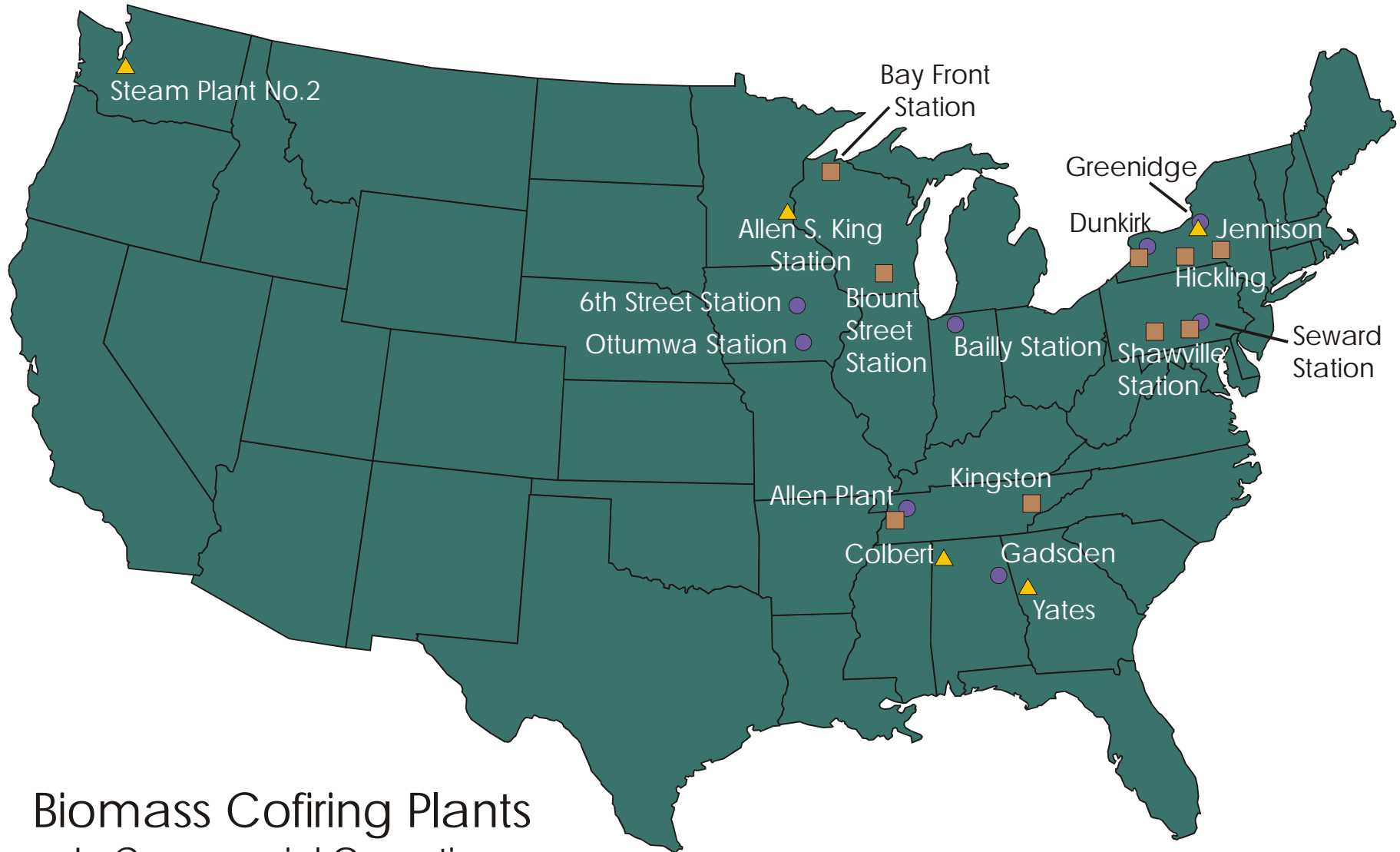
- EPRI
- Niagara Mohawk Power Corp.
- New York State Gas & Elec.
- IES Utilities
- TVA
- General Public Utilities
- NIPSCO
- Southern Companies
- Burlington Electric Dept.
- NY Gas
- SUNY, Cornell, Univ. Of Toronto
- Auburn Univ.
- NYSERDA
- Southern Research Inst.
- USDA

Projects:

- Salix (BPfRD)
- Chariton Valley (BPfRD)
- Southern Research cofiring project
- DOE/EPRI Cofiring Demonstrations
 - GPU (Seward)
 - NIPSCO (Bailly)
 - TVA (Allen)
- FETC/SNL/NREL Cofiring Collaborative
 - Supporting research



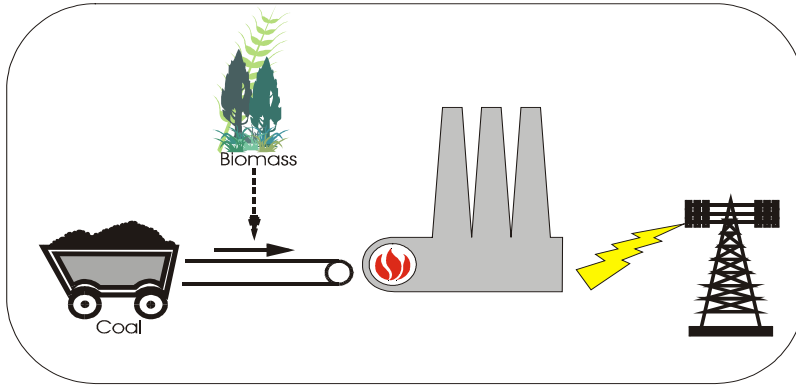
Biomass Cofiring in the U.S.



Biomass Cofiring Plants

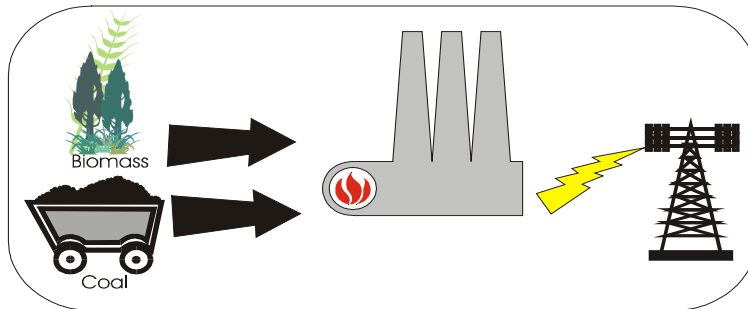
- ▲ In Commercial Operation
- Demonstrations Conducted
- Tests Planned

Paths to Cofiring



“Sprinkle” Method

Minimal equipment/cost
Limited to low-percentage cofiring
Co-mingles ash



Separate Firing

Two Methods

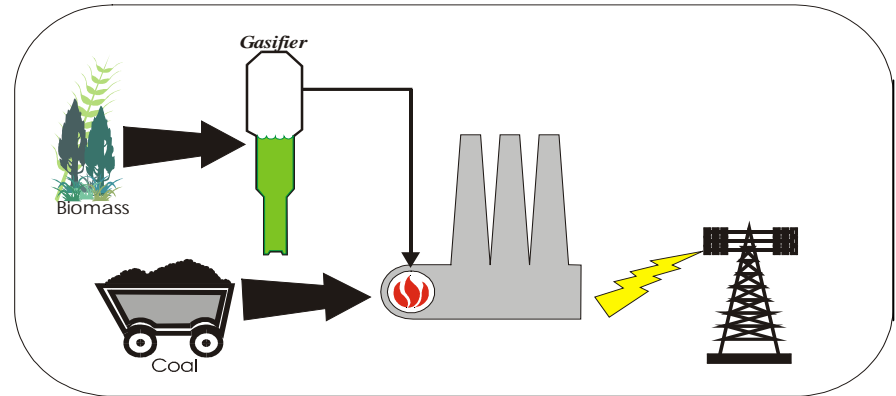
- Same mill (A)
- Separate mill (B)

Higher cofiring percentages possible (esp. B)

Additional cost (esp. B)

Mill throughput limitations (A)

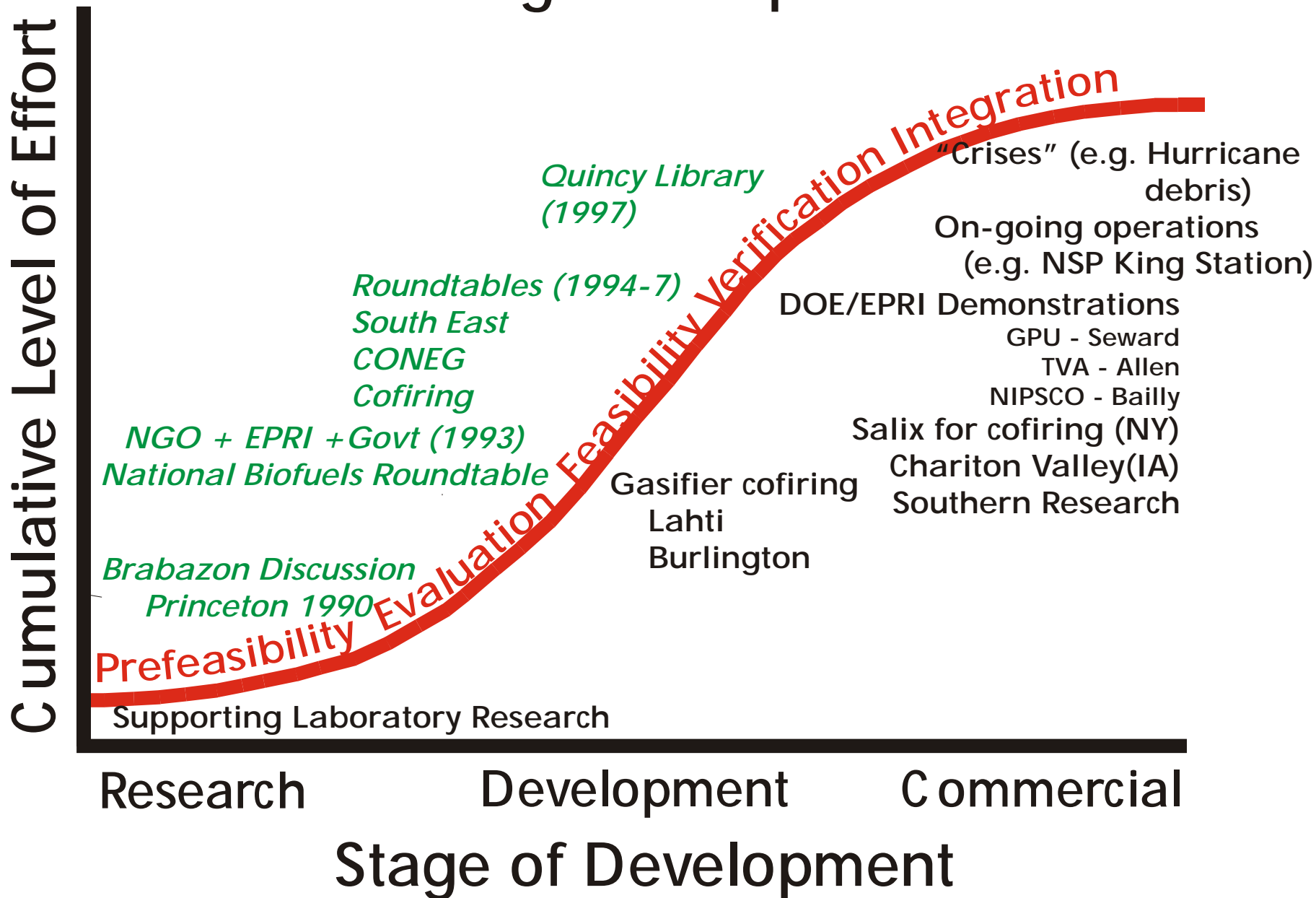
Comingles ash



Gasifier Cofiring

High percentage cofiring
Additional cost
Minimal impact on existing operation
Ability to use “problem” feedstocks
Potential for NO_x reburning
Segregates biomass ash

Cofiring Development



Cofiring Issues

- Potential for Power Loss
- Manpower requirements
- Emissions Impacts
 - Fuel NO_x
 - De-NO_x impacts
 - SO_x
 - TSP's
- Not widely perceived as “green”
- Potential Impact on Ash Sales
- Feedstock Infrastructure

DOE's Small Modular Biopower Projects

To provide power in the 5 kW - 5 MW range

To develop small modular biopower systems that:

- are fuel flexible
- are efficient
- are simple to operate
- have minimum negative impacts on the environment
- are for domestic and international markets

Multi phase Project:

Phase 1: Feasibility Studies

Phase 2: Prototype Development and Testing

Phase 3: Integrated Systems Demonstration

Team Management - DOE, NREL, SNL

DOE's Small Modular Biopower Projects

Phase 1 Contracts Awarded

Agrilectric	Fluid-Bed Combustor/Steam Turbine	500 - 5000kW
Bechtel	Gasifier/Engines/Gas Turbine	500 - 1500kW
Bioten	Direct-Fired Combustion Turbine	5000kW
Carbona Corp	Gasification/ Steam Turbine	1000 - 3000kW
Community Power Corp.	Gasification/IC Engine	10 - 25kW
EERC	Fluid-Bed Combustor/Steam Turbine	500 - 5000kW
Niagara Mohawk	Gasification/IC Engine/Gas Turbine	500 - 5000kW
Reflective Energies	Gasification/Gas Turbine	100 - 1000kW
STM	Gasification/Stirling Engine	25 - 70kW
Sunpower	Gasification/Stirling Engine	1 - 10kW



Working with Stakeholders



Independent testing
Technical support
Integration research
Next generation systems

Technical advice & support
Analysis Methods
Issue Identification
Independent analysis
Integration research
Technical solutions



Deployment
and Major Projects

Feedstock & Operational questions
Technical barriers
Technology needs

Operational Data
Feedstock questions



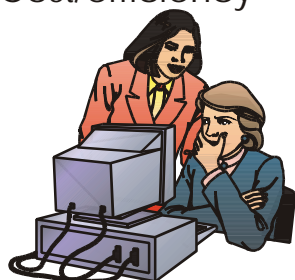
Plant Operators

Technical support
Analysis methods
Data management
Issue Identification

NREL
Experimental
Capabilities

Operational Data
Concept evaluation
Emissions data

Research priorities
Integration issues
Environmental impact
Life cycle analysis
Process designs
Cost/efficiency



Analysis

Modular Systems

Components
Operational questions
Market needs



Working with Stakeholders

